ARS 42-75
June 1963



# MANURE DISPOSAL LAGOONS

Agricultural Research Service

UNITED STATES DEPARTMENT OF AGRICULTURE

In cooperation with the

Maryland Agricultural Experiment Station

CONTENTS



Before constructing a manure disposal lagoon, consult local health authorities.

# MANURE DISPOSAL LAGOONS

by Harry J. Eby [1]

This publication reports the results of observations of manure disposal lagoons in several Eastern and Midwestern States and in Canada and reviews the available literature on the subject. Each lagoon was visited once in the summer and once in the winter. One eastern lagoon has been under continuous observation for more than 2 years. A bibliography is included.

The lagoon is not something new, although its application to farm use is recent. Lagoons have been used successfully by small municipalities for 40 years or more as a means of sewage disposal. They have also been used successfully for industrial waste disposal. Milk processing plants use them extensively.

The lagoon duplicates Nature's means of oxidizing organic waste. Sunlight, air, bacteria, single-celled aquatic life, and algae act on organic waste in the lagoon just as they act on this material in streams and lakes.

Sanitary engineers have done considerable research on sewage lagoons and have developed design criteria for them.

In areas of creviced limestone or sinkholes, lagoons may contribute to pollution of groundwater. Local Soil Conservation Service representatives should be consulted where a lagoon is being considered for construction. The local health officer should also be consulted about the possibility of contamination of water supplies.

## Lagoon Types

Manure disposal lagoons are of three types, based on the action that takes place in them--anaerobic, aerobic, or a combination of the two. Municipal sewage lagoons, however, are constructed to rather strict standards and are entirely aerobic.

The first type of manure disposal lagoon is an open pit or trench and is entirely anaerobic in action. It is septic and generally gives off unpleasant odors, especially during warm, humid weather. It fills in rapidly with sludge. An example of this is a hog feeding operation where the wastes from 3,000 hogs are flushed to such a facility. At 2-year intervals, the system is cleaned out. Approximately 1,800 cubic yards of sludge is removed at a cost of $1 per yard.

---

1/ Agricultural Engineer, Agricultural Engineering Research Division, ARS, USDA, College Park, Maryland.

The second type of manure lagoon has almost complete aerobic action. Here the liquid absorbs oxygen from the air. The algae present supply additional oxygen through the process of photosynthesis. Thus, the aerobic type of decomposition is promoted. This type of facility is sometimes referred to as an "oxidation pond". Aerobic decomposition produces almost no odor and gives a much better breakdown of organic matter than does anaerobic. These facts are brought out in studies of several municipal sewage disposal lagoons in North Dakota, where the estimated rate of sludge buildup would be about 1 foot in 135 years (based on a load factor of 1 acre of surface area per 100 population).

The third type is that in which there is a combination of aerobic and anaerobic action. This type produces fewer odors than the other two types and is probably more effective in breaking down the organic matter, so that a slower rate of sedimentation buildup can be expected. The organic matter is not entirely oxidized, but it is stabilized to a form that can be contained further without excessive fermentation. The term "stabilization pond" is sometimes applied to this type.

Existing farm ponds, if adequate in size, may be used as manure disposal lagoons. Because of the depths generally encountered, farm ponds would probably have a combination of aerobic and anaerobic action.

## How Lagoons Work

Manure contains numerous micro-organisms that inhabit intestinal tracts of animals. These organisms are an anaerobic type; that is, they live and multiply in the absence of oxygen. In the septic pit type of disposal system, where the action is entirely anaerobic, gases such as hydrogen sulfide, carbon dioxide, and methane are given off. Some of these gases, primarily hydrogen sulfide, have disagreeable odors. The bacteria are predominantly the type excreted by the animal itself.

In the oxidation lagoon, manure is subjected initially to an anaerobic or septic condition. This is a result of the following: Bulk manure is discharged into the lagoon where there is little or no oxygen, so that anaerobic conditions prevail. Thereafter, depending on wind action, solar absorption, mixing, and natural dilution, a gradual change to an aerobic condition occurs where different bacteria take over. Then aerobic bacteria oxidize the material, utilizing the oxygen in the liquid. This oxygen is supplied partly by absorption from the atmosphere and partly by the algae that are in the liquid. The algae utilize the carbon dioxide generated by the bacteria in their photosynthesis and release oxygen to the surrounding liquid. Further purification is achieved by the presence in the liquid of single-celled animal life in the form of paramecium, ameba, plankton, and protozoa. These are the lowest forms of animal life and exist primarily on bacteria. Their action reduces the bacteria count.

In the combination anaerobic and aerobic system, hydrogen sulfide, methane, and carbon dioxide gases are given off; but some oxidation due to absorption of some oxygen at the surface of the pond occurs.

## Construction of Manure Disposal Lagoons

Several factors must be considered in constructing a manure disposal lagoon: (1) Availability of land; (2) possibility of objectionable runoff that would degrade downstream water; (3) choice between a stabilization pond or a true oxidation pond; and (4) availability of enough water to maintain the lagoon.

For disposing of hog manure, one State agricultural extension service recommends a lagoon area equal to that of the feeding floor, which may be only 15 square feet per animal. This area produces a septic condition and some odors--but they are no worse, and frequently less bothersome, than those that come from the feeding floor.

Several installations were observed where the pond adjoins the feed floor. This arrangement is not recommended unless there is a retaining wall that will prevent seepage from softening the ground under the floor. Some floors that had cracked and sunk were observed.

Lagoons with a surface area of up to 20 square feet per animal showed septic conditions. The design criteria at which aerobic rather than anaerobic action occurs have not yet been definitely determined. However, population equivalents (table 1) have been developed for farm animals and poultry that make it possible to apply sewage lagoon design criteria to manure lagoons. Very large ponds have also been observed but not evaluated, because they are not typical.

Figure 1 shows the loading rates (the number of persons served per surface acre) permitted by the respective State Departments of Health for municipal sewage lagoons.

Table 1 correlates the number of humans that each listed animal is equivalent to with respect to biochemical oxygen demand (BOD) of waste products. This means that in a State where the requirements for a municipal lagoon are a loading rate of 100 population per surface acre, 1 surface acre will dispose of the wastes of 8.7 horses, 6.1 cows, 40.1 sheep, 50.3 hogs, or 7,000 chickens. Cooley and Jennings (7) 2/ reported finding no appreciable loss in efficiency with somewhat higher loadings than these, but the listed values should not be exceeded without concurrence of the local authorities.

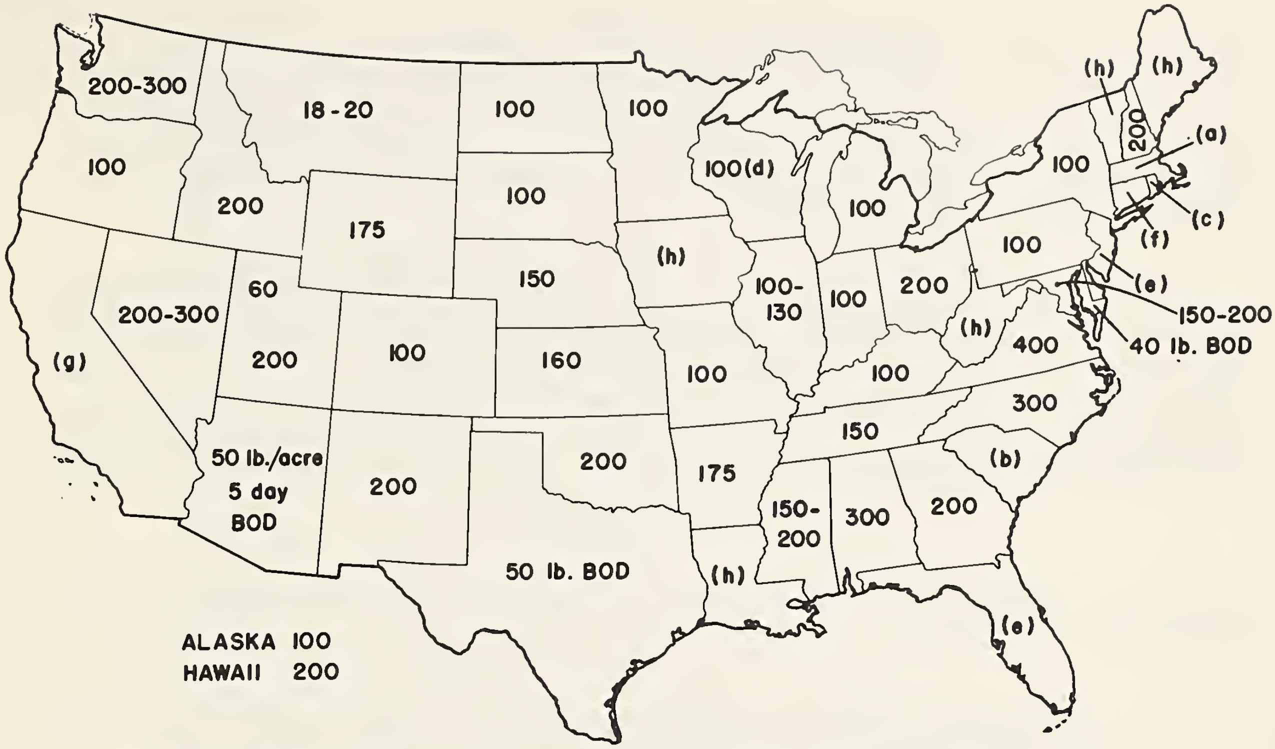
---

2/ See bibliography, page 10.

Table 1.--Allowable lagoon-loading rates that will assure complete oxidation of fresh material

| Waste from- | Population equivalent 1/ | Population per acre of surface area | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Man | 1 | 100 | 150 | 200 | 250 | 300 | 350 | 400 |
| Animals: | | | | | | | | |
| Horses | 11.4 | 8.7 | 13.2 | 17.7 | 22.1 | 26.5 | 30.8 | 35.1 |
| Cows | 16.4 | 6.1 | 9.2 | 12.2 | 15.2 | 18.3 | 21.4 | 24.5 |
| Sheep | 2.45 | 40.1 | 60.1 | 80.2 | 100 | 120.2 | 140.4 | 160.6 |
| Hogs | 1.9 | 50.3 | 70.9 | 100.6 | 132 | 150.8 | 179.6 | 200.4 |
| Chickens | .014 | 7,000 | 10,500 | 14,000 | 17,500 | 21,000 | 24,500 | 27,000 |

1/ Source: Henderson, J. M. Rough draft of initial sections of a report on waste disposal feasibility at the new animal farm of the National Institutes of Health, vicinity of Poolesville, Montgomery County, Maryland. (n. p.) (n. d. )




(a) Each application judged separately.
(b) 50 lbs. BOD/day/acre.
(c) Construction unlikely.
(d) 2 ponds required--the second 1/4 to 1/3 as large as the first.
(e) Not allowed.
(f) Only 2 (under experiment).
(g) No standards set.
(h) Information not available.

Figure 1.--Allowable loading rates for sewage disposal lagoons. (Population or lbs. BOD per acre of surface area, unless otherwise indicated.)

Larger lagoons should be constructed in accordance with standard pond construction methods. Information on these methods can be obtained from local Soil Conservation Service offices. A few modifications, however, should be considered. The walls of the lagoon below the liquid surface should be fairly steep, preferably vertical, to discourage aquatic weed growth and to eliminate mosquito breeding. The pipe or trough that carries the liquid manure to the lagoon should extend sufficiently far to discharge into the liquid at all times regardless of the level of the surface. Where discharges run off onto a bank and then into the lagoon, potential fly or other insect breeding conditions are created.

Banks above the surface should be kept as weed-free as possible. Use of weed-killing chemicals should be avoided, since they affect the biology of the lagoon and may interfere with the algae growth or stop it entirely. Herbicides used on fields contributing runoff water may also cause trouble. A small amount of weed killer would probably do no harm, but some fish and wildlife authorities believe that weed killers are detrimental to stream and pond management.

The liquid in an oxidation pond should be from 3 to 5 feet deep, and the bottom of the pond should be fairly level. Liquid this deep will hold down bottom weed growth and still be sufficiently shallow to allow sunlight to filter through to promote algae growth. The level bottom will prevent septic pockets from forming. Seeding the lagoon with any particular type of algae is not necessary. The chlorella genus is common and widespread and will probably develop naturally.

Under some circumstances, for example where the terrain does not permit construction of a single adequate lagoon, a series of small lagoons might be constructed. Or, a holding tank or trench might be built adjacent to the feed floor, in which the daily flushings could accumulate until they reached sufficient volume to properly flush material to the lagoon. This would accomplish two things: (1) It would allow a buildup of volume, and (2) primary septic action would take place in the trench during the initial buildup.

## Lagoon Management

For best results in managing a lagoon, these procedures should be followed:

1. Do not permit bedding of any kind, burlap bags, paper, or any floating material to enter the lagoon. Floating material interferes with the surface absorption of oxygen, reduces the penetration of sunlight for algae growth, and is unsightly and difficult to decompose. This is particularly true of poultry feathers.

2. Load the lagoon regularly and uniformly for maximum efficiency. Irregular, heavy loadings may overload the lagoon and result in a period of stagnation or may change it from an aerobic lagoon to an anaerobic lagoon.

3. Maintain a constant water depth.

4. Keep weeds mowed around the edges of the lagoon.

5. Fill the lagoon before running manures into it.

6. Agitate the surface with boards or an outboard motor if algae mats form on the surface. This will break up and sink the mats.

7. Do not allow petroleum products or other floating liquids to enter the lagoon. The effect would be the same as for floating material.

## GLOSSARY

The following definitions apply in this publication:

Aerobic.--Living or active only in the presence of oxygen.

Algae.--Small primitive plants usually associated with water, which may be single-celled or multicelled, may contain chlorophyll, and are capable of photosynthesis.

Anaerobic.--Living or active in the absence of oxygen.

Aquatic vegetation.--Vegetation that will grow only in, or close to, water.

Bacteria.--Single-celled organisms that are active in fermentation and conversion of organic matter to plant nutrients. Some are disease producers and others are harmless.

Biochemical oxygen demand (BOD).--That quantity of oxygen utilized in biochemical oxidation of organic matter during an incubation period of 5 days and at a temperature of 20° C.

Biological.--Referring to the processes of plant and animal life.

Herbicides.--Chemicals used to kill plants either selectively or indiscriminately.

Lagoon.--Used interchangeably with pond.

Oxidation.--The combining of oxygen with organic waste material to produce simple chemical compounds such as carbon dioxide, water, nitrates, etc.

Oxidation pond.--That type of pond wherein sufficient amount of oxygen is present to completely oxidize the waste matter that is fed into it.

Pathogenic bacteria.--Disease-causing bacteria.

Pesticides.--Chemicals used to kill insects either selectively or indiscriminately.

Photosynthesis.--Synthesis of chemical compounds effected with the aid of radiant energy, especially light. Specifically, the formation of carbohydrates in the chlorophyll-containing tissues of plants exposed to sunlight.

Septic.--A putrefactive condition produced by anaerobic decomposition of organic wastes, usually accompanied by production of malodorous gases.

Stabilization pond.--A pond where there is not sufficient oxygen to provide complete oxidation of the waste material, so that both anaerobic and aerobic actions take place.

## BIBLIOGRAPHY

(1) Anonymous.
(n. d.) Sewage lagoons or sewage oxidation ponds. A collection of articles for reference in design and construction. Underwood McLellan & Associates, Ltd., Calgary-Saskatoon, Winnipeg-Canada.

(2) Allen, M. B.
1955. General features of algal growth in sewage oxidation ponds. Pub. 13, Sacramento, Calif., State Water Pollut. Control Board. 48 pp.

(3) Berschauer, W. A.
1961. Sewage lagoon with a difference. The American City 76 (3): 88-90.

(4) Bogan, R. H.
1961. Removal of sewage nutrients by algae. Pub. Health Rpt. 76 (4): 301-308.

(5) Bush, A. F., Isherwood, J. D., and Rodgi, Shiva.
1961. Dissolved solids removal from waste water by algae. Jour. Sanit. Engin. Div. Proc. of Amer. Soc. Civ. Engin. 87, No. SA 3. Pt. I: 39-57.

(6) Caldwell, D. H.
1946. Sewage oxidation ponds--performance, operation and design. Sewage Works Jour. 18: 433-458.

(7) Cooley, C. E., and Jennings, R. R.
(n. d.) Study of the performance of a sewage stabilization pond at Farmville, Virginia, State Water Control Board, Richmond, Va. (n. p.)

(8) Federation of Sewage and Industrial Wastes Association.
1959. Sewage treatment plant design, manual of practices, No. 8, 375 pp.

(9) Gotaas, H. B., and Oswald, W. J.
1955. Photosynthetic reclamation of organic wastes. Proc. of the Solar Energy Symposium, Tucson, Ariz.

(10) Hermann, E. R., and Gloyna, E. F.
1956. The design of oxidation ponds. Ingenieria Sanitaria 9 (3): 39-50.

(11) ____________ and Gloyna, E. F.
1958. Waste stabilization ponds. I. Experimental investigation. Sewage and Indus. Wastes 30 (4): 511-518.

(12) Hermann, E. R., and Gloyna, E. F.
1958. Waste stabilization ponds. II. Field practices. Sewage and Indus. Wastes 30 (5): 646-651.

(13) ____________ and Gloyna, E. F.
1958. Waste stabilization ponds. III. Formulation of design equations. Sewage and Indus. Wastes 30 (8): 963-975.

(14) Hogge, H. L., and Dobko, S. L.
1960. Use of sewerage ponds in Alberta, Canada. Sect. 13. Proc. of symposium on waste stabilization lagoons, Kansas City, Mo. (n. p.)

(15) Johnston, J. E.
1960. Lagoon development and acceptance in Mississippi. Sect. 12. Proc. of symposium on waste stabilization lagoons, Kansas City, Mo. (n. p.)

(16) Mackenthun, K. M., and McNabb, C. D.
1959. Sewage stabilization ponds in Wisconsin. A report on biological and chemical investigations, April 1957-August 1958. Bul. Comm. Water Pollut., Wisconsin, No. W. P. 105. 52 pp.

(17) Neel, J. K., and Hopkins. G. J.
1956. Experimental lagooning of raw sewage. Sewage and Indus. Wastes 28 (11): 1326-1356.

(18) ____________ McDermott, J. H., and Monday, C. A., Jr.
1961. Experimental lagooning of raw sewage at Fayette, Missouri. Jour. Water Pollut. Control Fed. 33 (6): 603-641.

(19) Oswald, W. J., and Gotaas, H. B.
1955. Photosynthesis in sewage treatment, Sep. 686. Proc. Amer. Soc. Civ. Engin. 81: 27 pp.

(20) ____________ and Gotaas, H. B.
1957. Photosynthesis in sewage treatment. Paper No. 2849, Trans. Amer. Soc. Civ. Engin. 122: 73-97.

(21) ____________ Gotaas, H. B., Golueke, C. G., and Kellen, W. R.
1957. Algae in waste treatment. Sewage and Indus. Wastes 29 (4): 437-455.

(22) ____________ Gotaas, H. B., Ludwig, H. F., and Lynch, V.
1953. Algae symbiosis in oxidation ponds. III. Photosynthetic oxygenation. Sewage and Indus. Wastes 25 (6): 692-705.

(23) Pipes, W. O., Jr.
1961. Basic biology of stabilization ponds. Water and Sewage Works 108 (4): 131-136.

(24) Reid, G. W., and Assenzo, J. R.
1961. Culture and harvest of attached algae grown on domestic sewage. Part I. Water and Sewage Works 108 (6): 248-250.

(25) Sidio, A. D., Hartman, R. T., and Fugazzotto, Paul.
1961. First domestic waste stabilization pond in Pennsylvania. Pub. Health Rpts. 76 (3): 201-208.

(26) Smallhorst, D. F.
1953. Design and application of oxidation ponds. Pub. Works 84 (12): 89-90; 111-114.

(27) Thoman, J. R., and Jenkins, K. H.
1958. Statistical summary of sewage works in the United States. Pub. Health Serv. Pub. 609. 40 pp.

(28) Towne, W. W., Bartsch, A. F., and Davis, W. H.
1957. Raw sewage stabilization ponds in the Dakotas. Sewage and Indus. Wastes 29 (4): 377-396.

(29) __________ Bartsch, A. F., Davis, W. H., and Graves, Q. B.
1956. Waste stabilization ponds. A statement of cooperative studies in progress by the Public Health Service. 9 pp. (Processed)

(30) __________ and Horning, W. B.
(1961.) Some observations on the growth, application and operation of raw sewage stabilization ponds. Sect. 9. Proc. of symposium on waste stabilization lagoons, Kansas City, Mo., Aug. 1-5, 1960. (n. p.) (Processed.)

(31) United States Department of Health, Education and Welfare, Public Health Service.
1957. Sewage stabilization ponds in the Dakotas, Vol. 1. A joint report with the North and South Dakota Departments of Health. 87 pp.

(32) Van Heuvelen, W., and Svore, J. H.
1954. Sewage lagoons in North Dakota. Sewage and Indus. Wastes 26 (6): 771-789.

(33) Wennström, M.
1955. Oxidation ponds in Sweden. A study on the pond system at Lund. Lunds Universitets Årsskrift, N.F. Avd. 2. 51 (7): 1-58.

(34) Werkman, C. H., and Wilson, P. W.
1951. Bacterial physiology. Academic Press, N.Y. 707 pp.